Review and Recommendations for the Trinity, San Jacinto River Basins and Galveston Bay - Environmental Flow Work Plan (10 yr.)

Since 2011 with the adoption of the Environmental Flow Standards for the Trinity and San Jacinto Rivers and Galveston Bay and the subsequent development of the Work Plan in 2012 there have been numerous studies regarding various aspects of both instream flow and freshwater inflows in Texas. Specific projects have evaluated diverse information needs in the 2012 Work Plan Report including identification and recommendation of appropriate estuarine bioindicators, refinement of estimates of freshwater inflow, suspended sediment, evaluation of the response of primary producers to freshwater inflow including nutrients, geomorphology of the lower Trinity River, instream studies of hydrology, geomorphology and fish habitat suitability. Baseline monitoring studies of instream populations of mussels, fishes, and channel morphology and physical attributes were also conducted. Results of these studies have provided valuable information to evaluate the data needs for regulation of environmental flows in the Trinity and San Jacinto Rivers including the Galveston Bay estuary. This research has also illuminated the need for continued research and monitoring to better evaluate the attainment and if needed refinement of adopted flow standards.

Selected sections from our existing work plan which have not been adequately addressed and deserve priority in future work are highlighted below with accompanying elaboration. Newly recognized data gaps are also discussed. Some of the recommendations will modify what was described in the original work plan but are consistent with the intent of action items. These research and monitoring priorities are summarized below. This list should not be considered exhaustive but rather an addendum to the existing work plan priorities unless otherwise noted.

1) Instream Hydrology and Associated Water Quality

Based on data collected by the Trinity River project (TRA/ SB3) , it appears that flow patterns have changed and precipitation patterns seem to have altered. In recognition of these findings, we believe that there should be a study of the evolution of flow patterns post 1945 with a focus on the characterization of extreme events and alterations in their periodicity. Given the apparent change in degree and periodicity of extreme events, it is important to understand how the transport of nutrients and sediments are being affected. Extreme high flow events are likely to exhibit complex distributions of nutrient and sediment transport. As we now know, much of the high flow moving down the Trinity River moves out of the main channel before reaching the bay and we do not know how the nutrient and sediment content is impacted. Sediment distribution is key to the conservation of various habitats in the rivers and the bay.

While high flows have been of great recent concern, it is also important to understand the ecological value and contributions of different levels of base and subsistence flows. A lot of important things happen at high flows, but it seems that we have more control over what

happens at normal to low flows. These flows also seem to be the values most likely to be affected by water withdrawals.

U.S. Geological Survey has been funded to understand nutrient and sediment transport dynamics. Near term studies should elaborate on the relationship between flow and nutrient loadings from the rivers to the bay. Once data sets have been collected, studies will be needed to develop models which will assess statistical relationships between nutrient loadings and flow patterns. These in turn will influence modeling from primary productivity to higher trophic levels, including recreational and commercial fisheries stocks, that incorporate effects of freshwater inflow patterns.

Specific emergent research questions on hydrology and water quality found in the Work Plan include:

- To what extent have the low, high pulse, and flood flows in the river changed over time?
- Have extreme low or high flows become more frequent or extreme? (pg. 17 Work Plan)
- What are the primary causative factors associated with the observed patterns?
- What concentrations of nutrients are present at low, moderate, and high stream flow?
- What are the concentrations and loading of suspended solids and nutrient data during the rising limb and falling limb of wet weather flow events?
- What are the ambient water temperatures associated with various combinations of low stream flow and seasonal air temperatures?
- What sediment characteristics are associated with the different flow levels? (pg. 32)

2) Instream Biological and Geomorphological Response

We believe future instream studies should include the following components.

- Scientific process for establishment of new study areas
- Characterization of flow regime components at these sites. (pg. 21 Work Plan)
- Select representative short study site(s) within each long reach and in the bay for intensive work and long-term monitoring. Selection must include consideration of all four areas – hydrology, biology, water quality, and geomorphology.
- Prioritize the short reaches and begin intensive site-specific work to detail the flows at which key ecological functions occur. (pg. 27)

There is a need to establish study sites in Galveston Bay so that changes in the ecosystem can be more precisely characterized in relation to freshwater inflows. There is also a need for more study sites on the rivers and major tributaries. The systems being studied are dynamic and current data collection is either too narrow or not designed for an environmental flow purpose (e.g. TPWD randomized sampling). Characterizations at these sites should not be limited to flow or salinity data, but should include water quality, geomorphological and biological data. An additional objective of these studies is to examine the resilience of the ecological systems we are charged with understanding and protecting. After an extreme event, how long does it take

for the site to return to "normal" if it does. How does the lag time associated with resilience relate to the periodicity of extreme events?

3) Instream Mussel Studies

One of the most significant regulatory tools for conservation is the Endangered Species Act. Among the freshwater fauna, freshwater mussels are very strongly affected by changes in dams, flow patterns and resultant habitat alteration. Information on the distribution, relative abundance, habitat needs, and spawning requirements of mussels are largely lacking in both the San Jacinto and Trinity River watersheds. Some of these species are currently listed as threatened by the State of Texas. Quite a few of the native mussels in the Eastern US are federally listed as endangered. Currently some studies are being performed by US Fish and Wildlife Service on Texas mussels, but it is not clear how these findings may relate to the hydrology of river systems being studied by our BBEST. If data is available, we need to acquire it and evaluate the response of these species to hydrology. However, if relevant studies have not been done to determine the likelihood of ESA regulation of Trinity or San Jacinto essential habitat, then it should be commissioned. Basin wide surveys (e.g. diving, benthic sampling) should be conducted during base and subsistence flow levels to evaluate their distribution and habitat preferences and response to flow regimes. In addition, there is a critical need to identify the spawning requirements for mussels (i.e. critical habitat/flow requirements) (pg. 31 Work Plan).

4) Coastal Studies

The current assessment of the effects of freshwater inflow on the Galveston Bay ecosystem over long-term periods is hampered by the lack of an appropriate monitoring network. There is a need to establish study sites in Galveston Bay so that changes in the ecosystems can be more precisely characterized in relation to freshwater inflows. There is also a need for more study sites on the rivers and major tributaries. The systems being studied are dynamic and current data collection efforts are either too limited or not designed for an environmental flow purpose (e.g. TPWD randomized sampling).

As an example, at one extreme is the Coastal Fisheries Monitoring network that utilizes randomized probabilistic sampling design that employ oyster dredges, bag seines, trawls and gillnets to monitor shellfish, shore fishes, juvenile fish and invertebrates, and adult finfish. However, the scale of randomization is quite large to specifically answer questions at the entire estuary or coastal level. Due to the movement of sampling locations and the scale of ecological processes it is very difficult to conduct intense time series analyses. In addition, there is a complete absence of data matching the TPWD samples on benthic infauna, plankton and habitat (substrate type, vegetation coverage and species composition)[1]. In contrast, the majority of water and sediment quality monitoring in Galveston Bay is conducted at fixed sites

[1] TPWD has recently developed a new sampling protocol that includes limited habitat assessment.

usually monitored on a quarterly basis. Due to the non- probabilistic nature of this sampling design and low frequency of sampling, extrapolation to larger areas or regions is difficult. Automated logging measurements of water quality conducted by the TWDB occur only at a few (5-6) sites in the bay. The lack of spatial intensity limits the extrapolation of results to larger spatial scales and severely limits the ability to evaluate processes (e.g. movement of water masses).

Characterizations at estuarine sites should not be limited to flow or salinity data, but should include water quality, geomorphological and biological data. An additional objective of future studies would be to examine the resilience of the ecological systems. For example, resource managers should be able to evaluate extreme events (e.g. floods, droughts) and be able to answer basic questions like:

How long does it take for the site to return to "normal", if it does?

How does the lag time associated with resilience relate to the periodicity and magnitude of extreme events?

The development of a monitoring program consisting of 1) a stratified random sampling design that builds upon the TPWD coastal fisheries program and 2) a network of index sites at which water quality and biological/geochemical variables are measured. This would provide a powerful design for detecting spatial and temporal changes in critical indicators and processes. The spatial distribution and sampling intensity of this network could be developed after careful examination of past trends using statisticial methods such as power analysis. This would also provide managers with a tool to quantify how much of a change at what frequency we care to detect.

In order to determine in the future whether the Galveston Bay system is maintaining a sound ecological environment or not, a scientific description of the baseline conditions corresponding to a "sound ecological environment' and acceptable ranges of variation from the baseline indicator conditions must be established. When possible BBEST members should develop a proposed framework of baseline indicator parameters, the baseline values of these indicators and the acceptable range of variations that should be interpreted as corresponding to a "sound ecological" condition.

Baseline parameters and values should be drafted and modified as appropriate when future data are collected and/or analysis conducted. Selection of parameters and values is expected to be an iterative process, requiring regular comparison and analysis. Modification of selected parameters and values should be expected. Baseline parameters and values that are selected will be expected to vary naturally. One requirement should be to differentiate variation caused by freshwater inflow from variation caused by other factors. (pg. 43)

This baseline characterization should be associated with the fixed study sites or areas recommended above. Once baseline conditions are determined, they should be used to study the resilience of the estuarine ecosystem to extreme conditions (drought or flood of differing magnitude and duration). It should be possible to establish "expected" levels of individual indicator species density and community diversity using a biological data set and document typical lag times post flood and drought for diversity and abundance to return to levels observed pre-disturbance. It is recommended that permanent index sites be established for hydrological, water quality and biological monitoring.

5) Data mining and literature review.

There is a need to periodically review the scientific literature (agency reports, peer reviewed literature, theses/dissertations) to determine if new information has been generated that can help address data and research needs outlined in the Work Plan. This can be done by developing an information needs template that can be used to direct future reviews. The future review can be done formally in a periodic basis or "as you go" by interested BBEST members. An annotated bibliography can be developed that includes pdf copies of the reports/manuscripts, data (e.g. csv files), and metadata or summaries. Recent applicable data, and studies funded by the TDSHS, EPA, NOAA, TPWD, TWDB, TCEQ, HGAC, Clean Rivers Program, GBEP, HCFCD, TRA, SJRA, municipalities, TGLO, Texas Sea Grant, GOMA, NCCA, NRSA, USFWS/NWI, and the USCOE would be candidate sources. To the extent possible this should be hosted on a TRSJR BBASC web site or perhaps a joint effort by TWDB, TRA and the SJRA.

Additional Comments – Trinity River System

The Work Plan Report (2012) outlined 6 focus areas for additional study and analysis. Over the past several years, under SB2, SB3, and other funding mechanisms, significant work has been done to fill identified data gaps and to provide information for future analysis within the Senate Bill 3 framework and the adaptive management timeline for the Trinity River. Little work has been completed for the San Jacinto River. By design, the majority of the SB3 Instream work in the Trinity River has focused on providing tools and information for the upcoming adaptive management phase of the SB3 process, as opposed to recommending flows, indicator species, or completing detailed hypothesis testing of the existing SB3 flows.

While the research over the last 7 years has provided a valuable understanding of the hydrologic, hydraulic, connectivity, and sediment transport characteristics of the Trinity River, there have been relatively few fish and aquatic vertebrate data collection activities. For this, there are two reasons:

1) Extended record high flows and flooding in both the Trinity and San Jacinto Rivers limited opportunities for field work, and

2) It was decided at the beginning of the process that basin efforts would support the SB2 Texas Instream Flow Program (TIFP) process and that any additional data collection would be predicated on the findings from that study. To date, that study has not moved forward due to field conditions and prioritization of other river basins by the TIFP.

New Study Priorities:
We need to develop a series of questions and priorities, which the BBEST can then develop research projects to address. Example study questions are listed below.

Biological Study Areas

1. What species are ecologically significant for the Trinity River basin?
2. Is the use of indicator species appropriate and if so, which species could be used for that purpose?
3. When and how much backwater habitat needs to be inundated to support ecologically-significant/and or indicator species?

These are difficult questions and it is likely that indicator species would be based on subjective parameters. As shown in other basins in the state, the data does not readily indicate what is "ecologically important" due to the wide variability of priorities across the basin. Currently, Alligator Gar and Native Freshwater Mussels are topics of interest in the basin, but there is no guarantee that those species will remain top priority in the future. Furthermore, just because a given species may be enjoying high-visibility does not mean those species are appropriate indicators or are of significant ecological value.

Some additional potential candidate species and community assemblages include:

Possible Plant Indicators

Vallisneria – This species disappeared from the Trinity delta during the 2011 drought. There has been ongoing monitoring that documented the eventual return. There are other submerged aquatic plants that are sensitive to salinity, e.g. widgeon grass.

Trinity River wetlands (including Cypress swamp)
There is no scientific data on the extent and condition of Cypress swamp along the lower Trinity and no data on associated fish and invert populations.

Possible Animal Indicators
Macrobrachium ohione, river prawn, appears to be declining across its range which includes the Trinity. We have no information on how flow variation affects it.

Other suggestions include: Bull shark (lower tidal rivers extremely important nursery habitat); *Rangia* clam (ongoing monitoring, inconclusive results); Alligator populations

(apex predator could be important indicator); American Eel (candidate for listing as endangered).

Geomorphological and Hydrological Study Questions

1. impacts have recent high flows had on the physical characteristics of our river basins?
2. What flows cause channel scour, major bank failures, What river widening, etc.?

One important component for hypothesis testing in these systems are hydraulic models. These models are based on both field collected bathymetric and channel survey data, as well as flood plain topographic data. Because both the Trinity and San Jacinto Rivers have experienced record flows in recent years, the underlying floodplain elevations and channel bathymetry have changed which could affect the flows needed to inundate backwater habitat or move sediment, for example. More studies are needed of the impacts of extreme high flows on the physical and biological characteristics of the river basins supported by the collection of lidar and instream survey data.

Additional Comments – San Jacinto River System

There has been little if any work on the San Jacinto River system. In the original work plan there are numerous recommendations (page 28) including a specific recommendation to *Conduct a synoptic survey on each of the selected river reaches and tributaries under baseflow conditions*.

In addition, we recommend the following study areas.

1) A critical analysis of past, current and projected flow regimes that incorporates projected population growth, return flows, and interbasin transfer needs to be conducted.

2) Study the biological community to assess presence and extent of critical habitat for species of conservation interest.

3) What is the "normalized" nutrient loading for the San Jacinto River-Buffalo Bayou system after adjusting for human influence?